NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Streambank and Shoreline Protection

(Feet)

Code 580

DEFINITION

Using vegetation or structures to stabilize and protect banks of streams, lakes, estuaries, or excavated channels against scour and erosion.

PURPOSES

To stabilize or protect banks of streams, lakes, estuaries, or excavated channels for one or more of the following purposes:

1. To prevent the loss of land or damage to utilities, roads, buildings, or other facilities adjacent to the banks,
2. To maintain the capacity of the channel,
3. To control channel meander that would adversely affect downstream facilities,
4. To reduce sediment loads causing downstream damages and pollution, or
5. To improve the stream for recreation or as a habitat for fish and wildlife.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to natural or excavated channels where the streambanks are susceptible to erosion from the action of water, ice, or debris or to damage from livestock or vehicular traffic. It also applies to controlling erosion on shorelines where the problem can be solved with relatively simple structural measures, vegetation, or upland erosion control practices and where failure of structural measures will not create a hazard to life or result in serious damage to property.

CRITERIA

Criteria for streambank protection measures

Because each reach of a channel, lake, or estuary is unique, measures for streambank and shore protection must be installed according to a plan adapted to the specific site.

Designs for streambanks shall be according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

2. The grade must be controlled, either by natural or artificial means, before any permanent type of bank protection can be considered feasible, unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

3. Streambank protection shall be started at a stabilized or controlled point and ended at a stabilized or controlled point on the stream.

4. Channel clearing to remove stumps, fallen trees, debris, and bars that force the streamflow into the streambank shall be an initial element of the work.

5. Changes in channel alignment shall be made only after an evaluation of the effect on the land use, interdependent water disposal systems, hydraulic characteristics, and existing structures.

6. Structural measures must be effective for the design flow and be able to withstand greater floods without serious damage. They shall also be designed to avoid an increase in erosion downstream of planned measures.

7. When the streambank protection is to protect improvements such as buildings or structures, consideration will be given to items such as: (a) cost of the stabilization compared to the value of the structure(s) protected, (b) possibility of relocation of the structure needing protection, (c) remaining service life of the structure needing protection, and (d) effect of the streambank stabilization of the future management system of the landowner/user.

8. Extensive clearing of trees and brush along channel banks for the purpose of placing streambank protection will not be performed. Clearing under the area which streambank protection is to be placed is permissible. If removal of trees and brush is required, only the minimum necessary to accomplish the work will be performed. Lack of proper equipment to place the riprap or reduce construction costs are not justifiable reasons for removing more woody vegetation than absolutely necessary.

9. Vegetative protection shall be considered on the upper parts of eroding banks, especially on areas that are susceptible to infrequent inundation. When the 10-year frequency flow or the bank full flow has a velocity of 5 ft. per second or less, riprap or other nonerosive material to stabilize only the toe of the slope may be placed if all of the following conditions are met: (a) the upper edge or line of stabilizing material is 1 foot or more above the zone of saturation for base flow conditions on the bank slope, (b) banks have a slope of 2:1 or flatter, (c) the watershed or drainage area upstream from the area being protected is less than 100 square miles in size.

10. Scrap materials such as junked auto bodies will not be used for streambank or shoreline protection.

Streambank protection measures. The following is a partial list of elements that may be in a plan for streambank protection.

___Removal of fallen trees, stumps, debris, minor ledge outcroppings, and sand and gravel bars that may cause local current turbulence and deflection.

___Removal of trees and brush that adversely affect the growth of desirable bank vegetation.

___Reduction of the slope of streambanks to provide a suitable condition for vegetative protection or for the installation of structural bank protection.

___Placed or dumped heavy stone, properly underlain with a filter blanket, if necessary, to provide armor protection for streambanks.

___Deflectors constructed of posts, piling, fencing, rock, brush, or other materials that project into the stream to protect banks or curves and reaches subjected to impingement by high velocity currents.

___Pervious or impervious structures built on or parallel to the stream to prevent scouring streamflow velocities adjacent to the streambank.

___Obstructions, such as fences, to protect vegetation needed for streambank protection or to protect critical areas from damage from stock trails or vehicular traffic. Where needed, construct a permanent fence capable of excluding livestock from the streambanks. If livestock watering places are provided, the ramps leading to low water shall be on a slope of 4:1 or flatter. The ramps shall be surfaced with a suitable material to prevent erosion. Floodgates may be used at channel crossings, property and other fence lines.

___Banksloping. All banks to be seeded only and not riprapped shall be sloped to a 2:1 side slope or flatter. All material excavated from a

sloped bank may be placed on the bank, leveled, and seeded to prevent erosion during high water or hauled to other areas for use. Excavated material should not be pushed into the stream or lake or form barriers which interfere with runoff entering natural channels.

___Jetties. Brush, riprap, and/or piles may be used as deflecting jetties. Jetties must not extend out in the stream so the channel capacity is reduced.

___Revetments.

(1) Riprap. This type of construction is particularly effective in the following situations: (a) sharp bends; (b) constrictions such as bridges where velocities are increased; (c) along the opposite bank where another stream junctions; and (d) on large streams, the bank should be sloped to a 1 ½ side slope or flatter. The thickness and gradation requirements shall conform to criteria in Chapter 16 of the Engineering Field Manual.

(2) Gabions. Gabions are wire or plastic mesh baskets connected together and filled with rock in place. Banks shall be sloped to a 1.5:1 side slope or flatter. If the bank material is a fine-grained soil, use a well-graded pit-run sand and gravel filter or filter cloth.

___Stream Crossings. Stream crossings are installed to provide crossings for equipment and/or livestock. The crossing may consist of rubble or paved surfaces placed on the stream bottom and sides or may be culverts or bridges. NRCS does not provide designs for bridges. However, standard plans for timber bridges are available. Bridges and culverts must meet the requirements for capacity required by the Indiana Department of Natural Resources. Permits are usually required.

Crossing consisting of rock or rubble shall be placed in a manner which does not interfere with streamflows. Adequate thickness shall be provided to insure a firm base.

The following minimum guidelines shall apply for stream crossings:

(1) Firm Foundations - use on of the following:

a. 5 inches concrete over a minimum of 6 inches of pit-run sand-gravel or crushed stone.

b. 4 inches of surface gravel (IDOH size #5, #53 or #73) over 8 inches or more of crushed rock (d_{50} = 4”).

(2) Soft Foundations – use one of the following:

a. 5 inches concrete with 6 gate, 6” x 6” welded wire fabric over 6 inches pit-run sand and gravel or crushed stone.

b. 4 inches of surface gravel (IDOH size #5, #53 or #73) over 18 inches or more of crushed rock (d_{50} = 7-8”).

Crushed rock thickness should be increased 6 inches for equipment or vehicle crossings.

Concrete crossings shall be finished with a rough surface.

Ramps for livestock crossings shall not be steeper than 4 horizontal to 1 vertical. Ramps for equipment should be 6 horizontal to 1 vertical or flatter. Minimum width is 8 feet. Side slopes for ramps shall not be steeper than 2 horizontal to 1 vertical.

Standard plans shall be used when applicable.

Criteria for shoreline protection measures.

Design shall be according to the following principles.

1. Treatment depends on soil type and the slope characteristics both above and below the waterline. Slope characteristics below the waterline shall be representative of the slope for a minimum distance of 50 ft. from the shore.

2. End sections shall be adequately bonded to existing measures or terminate in stable areas.

3. Design water surface shall be the mean high tide or, in nontidal areas, the mean high water.

4. Control of surface runoff and internal drainage shall be considered in the design and installation of all protection measures.

5. Protection measures to be applied shall be compatible with improvements planned or being carried out by others.

6. No work of improvement may increase the potential for erosion on an adjacent reach of shoreline.

Shoreline protection measures. The following is a partial list of protection measures that may be used.

___Bulkheads (timber, metal piling, concrete, concrete block).

___Revetments (prefabricated slope protection blocks, riprap, soil cement, piling).

___Groin systems (timber or concrete).

___Vegetation of the type that will grow across or along the waterline.

___Bank Sloping. All banks to be stabilized shall be sloped to a 2:1 slope or flatter. All material excavated from sloped banks should be placed on the bank, leveled and seeded to prevent erosion from runoff or wave runup or hauled to other areas for use. Excavated materials shall not be pushed into the lake.

___Beaching Slope. Shore protection with beaching slopes utilizes the movement of semi-fluid sands up the beach with breaking waves, and off the beach with receding waves to dissipate energy. For any given wave size, a beach will stabilize with a particular relationship between beach slope and the median grain size of beach material. Criteria for design of beaching slope is contained in Chapter 16 of the Engineering Field Manual.

Requirements for the design of beaching slopes are:

1. The median grain size of the material larger than 0.17mm is used to represent the material.

2. The minimum median grain size material used shall be 0.5mm.

3. Minimum thickness of blanket is 1 foot.

4. Extend the slope protection below still water elevation a distance of two times the design wave height.

5. Extend protection above still water elevations a distance equal to the computed runup plus one foot.

6. Materials shall be place according to the thickness, slope and gradation contained in Chapter 16 of the Engineering Field Manual.

___Riprap. This type revetment protects shorelines from wave action, ice action and slumping due to seepage. Riprap shall be placed between 1.5 times the wave height below the still water surface and the runup plus 0.5 feet above the still water surface. The wave height (H) may be determined from Table 1. The runup (R) may be determined by multiplying the ratio (R/H) in Table 2 by the wave height (H). The D_{50} rock size in inches for various slopes and wave heights is shown in Table 3.

Table 1 – Wave Heights*

Fetch Distance (F)	Wave Height (H)
(ft)	(ft)
500	0.7
1,000	1.0
1,500	1.2
2,000	1.4
3,000	1.7
4,000	1.9
5,000	2.1
7,500	2.6
10,000	3.0
12,500	3.3

*H = 0.0392 F
Wind velocity = 50 mph

Table 2 – Ratio of Runup (R) Wave Height (H) for Various Shore Slopes

Shore Slope	Ratio
Horizontal:Vertical	R/H
2:1	2.3
3:1	1.9
4:1	1.5
6:1	0.9
10:1	0.5

Table 3 – D50 Rock Size for Various Shore Slopes and Wave Heights

Shore Slope (Horz:Vert)	Wave Height (H) (ft)	D_{50} Size (in)
2:1	1.0	4
	2.0	6
	3.0	8
3:1	1.0	4
	2.0	5
	3.0	7
4:1	1.0	4
	2.0	4
	3.0	7
6:1	1.0	4
	2.0	4
	3.0	6
10:1	1.0	4
	2.0	4
	3.0	4

Riprap shall be well graded with:

Percent passing by weight (%)	Size (inches)
100	2 x D_{50}
50-89	1.5 x D_{50}
25-50	D_{50}
10-30	0.5 x D_{50}
10	0.25 x D_{50}

A layer of bedding material no less than 6 inches thick or filter fabric is required on erodible soils. The bedding material shall be: 40-60% gravel (max. 3"); 40-60% sands; less than 5% finer than the #200 sieve.

On slopes 6 horizontal to 1 vertical and steeper, the riprap shall be anchored at the lowest elevation by excavating a "key-way" to a depth of 2 x D_{50} or increasing the thickness to 4 x D_{50} for a horizontal distance of 8 x D_{50}.

___Gabions. Gabions are wire or plastic mesh baskets connected together and filled with rock in place. They are flexible and stable if properly designed and installed. Like riprap, the apron will settle and conform to the final lake bed contour. Banks shall be sloped to a 1.5:1 side slope or flatter.

___Concrete. Concrete revetments for shore protection may be either (1) a sloping concrete apron which provides a nonerosive surface for waves to break against and run up on, or (2) a bulkhead type revetment used where steep banks prohibit the use of sloping forms of protection. The force of the waves acts on the bulkhead primarily in a horizontal direction. Footings for these structures should extend a minimum depth of 3 times the wave height below still water elevation. The top of the revetment should extend a minimum of 1 foot plus runup above still water elevation.

___Piling. Piling is another type of revetment used where natural shorelines are too steep for sloping protection. Piling may be installed either vertically or with a slight batter. Minimum thickness for piling are:

Material	Minimum Thickness (inches)
Metal Sheet	0.109
Wood Plank	2.0
Wood Pole	4.0

Wood planks and poles shall be pressure treated. The land side of piling should be backfilled to absorb wave energy. For design of piling, the lake bottom may be considered stable at a depth of three times the wave height below still water elevation. The top of the piling should be 1 foot plus runup above still water elevation.

___Groins. Groins are used to replace beach material removed by long shore currents. With the beach restored, waves break further from shore, reducing erosion on the bank. Groins are effective only where appreciable long shore currents exist. If the amount of sand carried by long shore currents (littoral drift) is small, the areas between groins may have to be artificially filled to establish a beach. Since the placement of groins tends to increase erosion on unprotected downdrift reaches of shoreline, location must be selective. Groins may be built of riprap, timber, steel, or gabions.

Vegetative protection. Vegetation will be established on all disturbed areas such as channel and shoreline slopes, berms, spoil and other areas except where the slopes are permanently covered with water or where streambank or shoreline protection measures are placed or land use conditions are such that vegetation is impractical. Seedbed preparation, seeding, fertilizing, and mulching shall comply with practice standard Critical Area Planting (342). The vegetation shall be maintained and tree and brush controlled by hand, machine or chemicals as needed.

CONSIDERATIONS

Effects on water quantity and quality shall be considered. This practice will have a minor effect on the quantity of surface and ground water. There may be increased erosion and sediment yield from the area and surrounding areas during and immediately after construction. There should be minimal effect after the first period of use and establishment of the protection and vegetation of disturbed areas. This practice will decrease the flow and base load of the stream on which it is applied to protect the streambanks. When it is installed to protect shorelines, there can be local enhancement of water quality, but, generally, the shoreline is protected and there are only slight benefits on water quality.

Special attention shall be given to maintaining and improving visual resources and habitat for fish and wildlife where applicable. The landowner/user will be advised if wetlands will be affected and USDA-NRCS wetland policy will apply. All work planned shall be in compliance with General Manual title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations.

Consideration shall be given to the use of construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc.

PLANS AND SPECIFICATIONS

Plans and specifications for streambanks and shoreline protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction specifications

General. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance fish and wildlife will be used where practical. Trees, stumps, and brush removed from the construction area may be piled for fish and wildlife habitat when approved by the landowner/user.

The completed job shall present a workmanlike appearance and conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

Site preparation. Special attention shall be given to protecting and maintaining key shade, food, den trees, and visual resources. Removal

of any trees and brush shall be done in such a manner as to avoid damage to other trees and property.

All trees, stumps, brush, and similar materials are to be removed from the site or disposed of in such a way as to have the least detrimental effect on the environment.

Excavation. To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the protection. All surplus or unsuitable materials shall be disposed of in a manner that will not interfere with the functioning of the protection.

Fill placement. Material placed in the fill areas of the protection shall be free of detrimental amounts of sod, roots, frozen soil, stones over 6 inches in diameter and other objectionable material. To the extent they are suitable, excavated materials are to be used as fill. The distribution and gradation of materials shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material.

Moisture control. The minimum moisture content of the fill material and foundation shall be such that, when kneaded in the hand, the fill material will form a ball, which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compaction equipment.

Topsoiling. Topsoil shall be removed and stockpiled on areas where establishment of vegetation is a problem on exposed subsoils (all subsoils except loam, silt loam and sandy loam, except where dense till is present). Topsoil shall be respread to provide a seedbed.

Where subsoil is exposed or is used in construction, topsoil will be placed in accordance with the following criteria.

- A minimum of four inches of topsoil ("A" horizon) will be placed where six or more inches of friable soil material with good moisture holding properties (more than 0.15 inches per inch) lies below the surface of the constructed surface.

- A minimum of eight inches of topsoil ("A" horizon) will be placed where less than six inches of friable soil materials with good moisture holding properties (more than 0.15 inches per inch) lies below the surface of the constructed surface.

- Topsoil will be placed in final shaping operations. The underlying soil, if needed, will be chiseled or scarified to permit proper bonding of topsoil.

Materials. The riprap material shall conform to the gradation shown on the drawings and be a durable rock. Riprap shall be dumped or placed in the manner consistent with good construction procedures and to the lines and grades shown on the drawings.

The area to be covered with a filter fabric or filter blanket shall be reasonably smooth. An even thickness of filter material shall be placed on the prepared surface. Care shall be exercised when placing the riprap to insure that the blanket is not ruptured or displaced.

Wire mesh baskets, when used for gabions, shall be fabricated from corrosion-resistant material to contain the rock material. Durable rock shall be used to fill gabions. The maximum dimension of individual rock particles shall not exceed one-half the minimum basket dimension. Minimum rock dimensions shall exceed the mesh size used in the basket construction. Soft materials such as sandstone and shale shall not be used. The foundation shall be smoothed and filter material, if required, shall be properly placed under and behind the gabions. The baskets shall be assembled in accordance with the manufacturer's recommendations.

Finish and cleanup. Construction areas will be finished in a relatively smooth condition ready for seeding. All rocks 3" in diameter or larger and roots shall be removed from the areas.

Vegetative establishment

Vegetation will be established on all disturbed areas such as channel and shoreline slopes, berms, spoil and other areas except where the slopes are permanently covered with water or when bank materials or land use conditions are such that vegetation is impractical. Trees and shrubs should be established where practical. Disturbed areas are to be seeded or planted to trees as soon as possible after exposure. Use daily seeding whenever possible. Planned trees and shrubs shall be established according to Technical Guide Specification 612, Tree/Shrub Establishment.

Gullied and uneven areas should be smoothed before attempting to prepare seedbed.

If needed, apply lime to raise the pH to the level desired for species of vegetation being seeded.

Fertilize according to soil tests or at a minimum rate of 1000 lbs. of 12-12-12 fertilizer (or its equivalent) per acre as soon as the measure has been constructed within the seeding periods. Apply 150 lbs. per acre of ammonium nitrate 6-8 weeks after seeding on soils low in organic matter and fertility.

Work the fertilizer and lime into the soil to a depth of 2-3 inches with a harrow or disk.

Prepare a firm seedbed with a cultipacker or cultipacker type seeder.

Seed one of the following grass mixtures during the preferred seeding periods of March 1 to May 10 or August 10 to September 30.

When construction is completed between May 11 and August 9, a temporary cover crop should be established using one of the following:

Species	Minimum Rates
(1) Wheat	150#/acre
(2) Rye	150#/acre
(3) Spring oats	100#/acre
(4) Annual rye grass	20#/acre
(5) Corn	150-300#/acre

After August 10, temporary cover shall be removed or incorporated, fertilizer applied, seedbed prepared and permanent seeding done in normal manner.

On critical sites, mulch with 1-1/2 to 2 tons straw per acre. Anchor the mulch with asphalt spray, netting or a mulch anchoring tool. In areas such as sharp breaks in shoreline or channel slopes or where excessive velocities could cause bank scour, paper netting, jute netting, rock lining, erosion control blankets or sod should be used.

Streambank and Shoreline Seed Mixtures

Species	Seeding Rate (PLS) (lbs/ac)	Seeding Rate (PLS) (lbs/100 ft$^{2)}$)	Suitable pH	Site Suitability: Droughty	Site Suitability: Well-drained	Site Suitability: Wet
1. Tall fescue	20	0.5	5.5 – 8.0	1	1	1
Smooth bromegrass	20	0.5				
2. Tall fescue	20	0.5	5.0 – 7.5	1	1	1
Reed Canarygrass	20	0.5				
3. Kentucky bluegrass	15	0.375	5.5 – 7.0	2	1	2
Creeping red fescue	15	0.375				
Redtop	3	0.07				
4. Tall fescue	30	0.75	5.0 – 7.5	2	1	1

PLS – Pure Live Seed
Site Suitability: 1 – Preferred, 2 - Acceptable

Mixture 3 may be used through urban or similar areas where lower growing vegetation is desired and close mowing will be practiced, also withstands shade better.

Five pounds of crownvetch seed per acre may be added to mixtures 1, 2 or 4 where high banks will be infrequently flooded.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze protected area during vegetative establishment and when soil conditions are wet.

2. Fertilize to maintain a vigorous vegetative cover. Caution should be used in fertilization to maintain water quality.

3. Control tree and brush growth as needed by hand, mechanical or chemical means.

4. Promptly repair eroded areas in or adjacent to the protected area.

5. Reestablish vegetative cover immediately where scour erosion has removed established seeding.

6. Periodically inspect area for any undermining or instability. If any undermining or instability is observed, take immediate action to protect from further damage.